

Eocidaris scrobiculata (Sandberger).

Fig. 5. Holotype. Interambulacral, original of Sandberger, pl. xxxv. fig. 3.

Miocidaris keyserlingi (Geinitz).

(a) Specimens from the Zechstein of Pössneck.

Fig. 6. Greater part of an interambulacrum, interior view, showing imbricate sutures, denticulation of adambulacral margin, and peristomial structures. Brit. Mus. E. 1121.

Fig. 7. Radiole, incomplete distally, longitudinally striate. Brit. Mus. E. 14,104.

Fig. 8. Interambulacral, to show nature of tuberculation. Brit. Mus. E. 1121, on another part of the rock-fragment that bears the original of fig. 6.*

(b) Specimens from the Magnesian Limestone of Tunstall Hill :
topotypes of *Cidaris verneuiliana* King.

Fig. 9. Greater part of an interambulacrum, interior view, showing denticulation of adambulacral margin and peristomial structures.

Fig. 10. Interambulacrals, from the adapical region of a small individual, showing slight interradiol tuberculation.

Fig. 11. Interambulacral from ambital region of a larger individual, showing well-marked scrobicular tubercles.

Fig. 12. Interambulacral from ambital region, with scrobicular tubercles not distinguished from the dense interradiol tuberculation.

Fig. 13. A similar interambulacral, with rather less interradiol tuberculation.

Fig. 14. Radiole, subcylindrical, longitudinally striate, non-muricate.

Fig. 15. Radiole, fusiform, muricate in longitudinal series.

Fig. 16. Radiole, fusiform, muricate in transverse series.

Fig. 17. Radiole, subfusiform, very slightly muricate.

Figures 1-5, representing *Eocidaris*, are enlarged 3 diameters. All are based on photographs, but owing to the dark colour and obscurity of the specimens the details have been emphasized.

Figures 6-17, representing *Miocidaris*, are enlarged 6 diameters.

Photographs by Mr. H. Herring. Drawings by Mr. G. T. Gwilliam and Mr. A. H. Scarle, under the direction of the author.

XI.—On the Anatomy and Classification of the Scombroide Fishes. By C. TATE REGAN, M.A.

MOST schemes of classification of the Teleostean fishes include a group Scombroidei or Scombriformes, comprising the Scombridae and Carangidae and a varying number of other families supposed to be related to them. In Boulenger's classification the Scombriformes form a division of the Acanthopterygii, but it is admitted that no good definition

of them can be given, and, as a matter of fact, none of the characters used to separate them from the Perciformes is really distinctive.

The discovery that the Trichiurid genera *Lepidopus* and *Eupleurogrammus* do not conform to Boulenger's definition of the Acanthopterygii, as the pelvic bones are remote from the cleithra (clavicles) and only connected to them by a long ligament, has led me to look into the anatomy of the Scombriform fishes.

As a result I find that the Carangidæ, Rhachicentridæ, Coryphænidæ, Bramidæ, and Menidæ show no special affinity to the Scombridæ and may be placed with the Percoids, but the remainder of Boulenger's Scombriformes is a natural group, which still includes so great a diversity of forms as to be with difficulty definable.

It is worth notice that none of the five families mentioned above as rejected from the Scombriformes is known before the Upper Eocene, but that the true Scombroïds were abundant in the Lower Eocene (London Clay), from which forms quite as specialized as any living at the present day are known.

This early specialization of the Scombroïds makes it necessary to consider whether the indirect attachment of the pelvic bones to the cleithra in the Trichiuridæ may not be a primitive feature. That this is not the case is shown by the fact that in all the members of the group which have well-developed pelvic fins, the pelvic bones are directly attached to the cleithra—*i. e.* their anterior extremities are firmly imbedded in the ligament which connects the cleithra above the symphysis*. In *Lepidopus* and *Eupleurogrammus* the pelvic fins are reduced to a pair of scales and the pelvis to a small spicular bone, connected by a long ligament with the symphysis; this condition may be regarded as secondary and due to the degeneration of the fins.

Consequently the Scombroïds may be regarded as an early offshoot from the Percoid stem, agreeing with the Perches in most characters, but differing in certain features of specialization.

Before proceeding to the classification of the true

* *Epinnula*, the most generalized Trichiuroïd, is not represented in the British Museum. Dr. Th. Gill very kindly examined the specimen of *E. magistralis* in the Smithsonian Institution and wrote to me, "the pelvic bones are attenuated forwards and terminate in a ligament connecting with the 'clavicles' at their symphysis." These words describe the condition I observe in *Thyrsites*, but on dissecting away the ligament in which the pelvic bones terminate I find that the latter extend forward, enclosed in a ligamentous sheath, to between the cleithra.

Scombroids some account of five families which have hitherto been placed with them is necessary. These are:—

1. Carangidæ.

The more generalized members of this family (*Seriola*, *Noucrates*) have the anatomical characters of the Serranidæ, there being nothing in the structure of the cranium, vertebral column, or pectoral arch to differentiate them from the latter, whilst genera like *Scombrops* and *Pomatomus* (*Temnodon*) connect the two families. In the Carangidæ the caudal peduncle is more slender, the caudal fin more widely forked, and the hypural embraced to a greater extent by the bases of the caudal fin-rays than in the Serranidæ, but the close relationship of the two families is evident.

2. Rhachicentridæ.

Rhachicentrum has a broad depressed cranium, but the relative position of the bones is as in normal Perciformes and as in the Carangidæ—*i. e.*, the parietals and epiotics are separated by the supraoccipital, the opisthotics and exoccipitals extend forward to the prootics, the prootics give rise to an osseous roof for the myodome, alisphenoids and a basisphenoid are present, but no orbitosphenoid, the præmaxillaries are protractile and have a pair of posterior processes which slide backwards and forwards on each side of a keel on the ethmoid, and the maxillaries are expanded distally. Owing to the depressed form of the cranium the basioccipital forms the floor of the *foramen magnum*, and the exoccipitals are widely separated below; this feature has no importance, as in the Carangidæ both conditions (basioccipital entering and excluded from the *foramen magnum*) are to be met with.

The pectoral arch is exactly as in generalized Percoids. The vertebral column consists of 25 vertebræ (11+14); there are 9 pairs of ribs, all but the first of which are inserted on short parapophyses: the epipleurals are attached either to the ribs near their point of insertion or to the vertebræ just above it. The caudal fin is lunate and the rays do not embrace the hypural to a greater extent than in Perch. However much the group Perciformes may be restricted, I cannot see how this type is to be excluded from it.

3. Coryphænidæ.

In *Coryphæna* the relative position of the cranial bones is as described in *Rhachicentrum*.

The skull is chiefly remarkable for the high median occipital crest continued forward to above the ethmoid, its anterior portion formed by the frontals. The ethmoid is hollowed out anteriorly for the reception of the vertically placed posterior processes of the præmaxillaries. There are 30 to 33 vertebræ, the præcaudals without parapophyses, the ribs and epipleurals inserted together on the centra. The structure of the pectoral arch and of the caudal fin is as in the Carangidæ, to which family the Coryphænidæ may be related.

4. Bramidæ.

The cranium of *Brama* is strikingly similar to that of *Coryphæna*. The family is distinguished from the preceding by the expanded coracoids and by the structure of the vertebral column, which comprises 42 to 47 vertebræ and has most of the ribs attached at the extremities of closed hæmal arches.

5. Menidæ.

Mene appears to be related to *Brama*, which it resembles in the structure of the occipital crest, but from which it differs in that the epiotics meet behind the supraoccipital. The mouth is very protractile and the maxillaries are abnormal, with the inner apophyses much elongated, and moving in a pair of grooves on the anterior surface of the vomer. This recalls the condition in the *Allotriognathi*, but differs from it in that the maxillaries are non-protractile, each being attached to the well-developed maxillary process of the palatine. The vertebræ number 23 (9+14) and the anterior ones are much abbreviated; the ribs are inserted on transverse processes, except the first pair, which are sessile on the third vertebra, are much enlarged, and are modified for articulation with the inner posterior edges of the post-cleithra; the transverse processes of the fourth and fifth vertebræ are enlarged and support the first pair of ribs from behind.

None of the five families mentioned above appears to me to be related to the Scombridæ; they may all be regarded as more or less specialized Percoids. The Carangidæ, Coryphænidæ, and Bramidæ have a perch-like mouth accompanied by a widely forked caudal fin, with the hypural bone embraced to a considerable extent by the bases of the caudal fin-rays; but that this latter feature does

not really indicate relationship to the Scombridæ is shown by the fact that *Thyrsites* has the hypural exposed to the same extent as in most Perches, but is otherwise so similar to *Scomber* in its anatomy as to leave little doubt that the two genera are closely related.

Recently, in the Introduction to the "*Pisces*" volume of the 'Biologia Centrali-Americana,' I instanced three apparently natural groups, each of which included forms with the pelvic bones firmly attached to the cleithra and others with the pelvic bones remote from them; to these the Scombroidei may now be added.

Order PERCOMORPHI.

Suborder SCOMBROIDEI.

Air-bladder without open duct. Maxillaries more or less firmly attached to the non-protractile præmaxillaries, which are typically produced and pointed anteriorly*. Cranium with the orbito-rostral portion elongate and the postorbital portion abbreviate; parietals separated by the supra-occipital; no orbitosphenoid; basisphenoid present; prootics giving rise to an osseous roof for the myodome. Vertebral column of solid centra which are co-ossified with the arches. Pectoral arch attached to the cranium by a forked post-temporal; no mesocoracoid; pterygials more or less regularly hourglass-shaped, 4 in number, 3 of them attached to the scapula. Pelvic fins of a spine and 5 soft rays or variously reduced, thoracic or subthoracic in position, the pelvic bones attached to the clavicles.

Division I. TRICHIURIFORMES.

Caudal fin-rays not deeply forked at the base, the hypural in great part exposed. Præmaxillaries beak-like, free from the nasals; mouth toothed, with lateral cleft; strong anterior canines. Epiotics separated by the supraoccipital. Gill-membranes free from the isthmus. Pectoral fins placed low.

Family 1. Gempylidæ.

Body oblong or elongate, compressed; maxillary exposed; spinous dorsal longer than the soft; anal with 3 spines,

* The very aberrant and highly specialized *Luxarus* is the only exception.

similar to the soft dorsal; each pelvic fin of a spine and 5 soft rays or reduced to a spine only; caudal fin present. Rays of the spinous dorsal equal in number to the vertebræ below them, each interneural usually attached to a neural spine; rays of soft dorsal and anal more crowded (except the isolated finlets, when present), about twice as numerous as the corresponding vertebræ; pelvic bones separate, anteriorly extending forward to the cleithra and firmly imbedded in the ligament between them. Vertebræ 31 (15 + 16) * to 53 (28 + 25); anterior præcaudals without parapophyses, with sessile ribs; posterior præcaudals with ribs attached at the extremities of closed hæmal arches; epipleurals attached to the centra.

Epinnula, *Ruvettus*, *Thyrsites*, *Nealotus*, *Prometichthys*, *Gempylus*.

The Oligocene *Thyrsitocephalus* appears to belong to this family.

Family 2. Trichiuridæ.

Body very elongate, strongly compressed; maxillary sheathed by the præorbital; spinous dorsal, if distinct, not longer than the soft; anal with numerous short spines; pelvic fins reduced to a pair of scale-like appendages, or absent; caudal small or absent. Dorsal and anal rays corresponding to the vertebræ, each interneural or inter-hæmal attached to a neural or hæmal spine; pelvic bones, if present, united to form a slender spicular bone connected with the cleithra by a long ligament. Vertebræ numerous, 100 (43 + 57) to 159 (39 + 120) or more; ribs feeble, sessile.

Aphanopus, *Evoxynepton*, *Lepidopus*, *Benthodesmus*, *Eupleurogrammus*, *Trichiurus*.

Lepidopus is known from Oligocene deposits.

Division II. SCOMBRIFORMES.

Hypural nearly or quite hidden by the deeply forked bases of the caudal fin-rays. Præmaxillaries beak-like, free from the nasals, which are separated by the ethmoid; mouth toothed, with lateral cleft; no canines. Epiotics separated by the supraoccipital. Gill-membranes free from the isthmus. Pectoral fins placed high.

* I am indebted to Dr. Gill for a radiograph of *Epinnula*, which shows the vertebræ to number 31 (15 + 16). In *Thyrsites prometheus* there are 34 vertebræ.

Family 1. Scombridæ.

Body fusiform; spinous dorsal not longer than the soft; anal with 1 to 3 feeble spines; posterior rays of soft dorsal and anal forming separate finlets; each pelvic fin of a spine and 5 branched rays; pelvic bones extending forward to the cleithra. Vertebrae 31 to 66; anterior præcaudals without parapophyses, with sessile ribs; posterior præcaudals with ribs attached at the extremities of closed hæmal arches; epipleurals on the centra.

Scomber, *Thunnus*, *Acanthocybium*, *Gastrochisma*, &c., allied genera commence in the Lower Eocene.

Division III. LUVARIFORMES.

Hypural nearly or quite hidden by the bases of the caudal fin-rays. Maxillaries broad and thin, attached to the feeble præmaxillaries, which are not produced into a beak and have short ascending processes for attachment to the ethmoid. Mouth small, anterior; teeth very feeble. Epiotics much enlarged and meeting behind the supraoccipital, which is carried forward to above the ethmoid. Gill-membranes broadly joined to the isthmus. Pectoral fins placed rather low.

Family 1. Luvaridæ.

23 vertebrae; ribs sessile. Post-temporal fused with the supra-cleithrum. Pelvic bones united. Dorsal and anal rays flexible, non-articulated.

Luvarus imperialis, a large pelagic fish resembling a Tunny, is the only known species.

Division IV. XIPHIIFORMES.

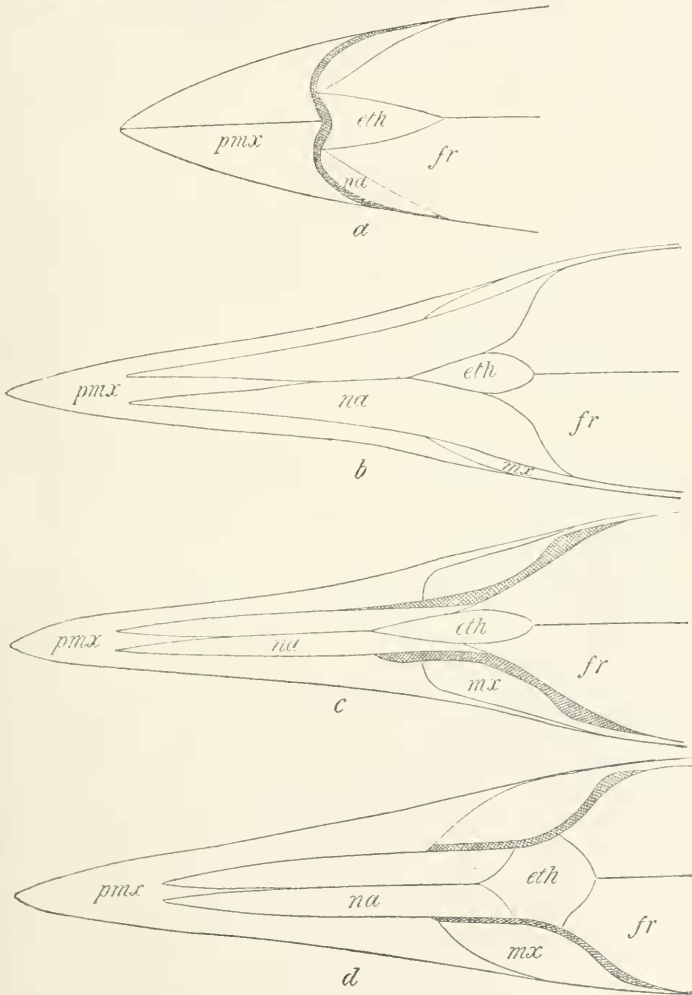
Hypural nearly or quite hidden by the bases of the caudal fin-rays*. A long pointed rostrum, formed by the united præmaxillaries and by the nasals, the latter meeting in front of the ethmoid and then diverging and tapering forward. Mouth with lateral cleft; teeth small or absent. Epiotics separated by the supraoccipital. Gill-membranes free from the isthmus. Pectoral fins placed low.

* Owing to the courtesy of Dr. Smith Woodward I have been able to verify this character in *Palæorhynchus* and *Blochius*.

Family 1. Palæorhynchidæ.

Vertebræ 50 to 60 in number ; pelvic fins 6-rayed. Neural and hæmal spines with thin posterior laminar expansions. Scales, if present, thin and cycloid.

Palæorhynchus and *Hemirhynchus* from Eocene, Oligocene, and Miocene deposits.



Diagrams showing the structure of the rostrum in *Acanthocybium* (a), *Histiophorus* (b), *Xiphias* (c), and *Xiphiorhynchus* (d).
 pmx, præmaxillary ; mx, maxillary ; na, nasal ; eth, ethmoid ;
 fr, frontal.

Family 2. *Histiophoridae*.

Vertebrae 24 or 25 in number; pelvic fins 1- to 3-rayed. Neural and hæmal spines expanded into strong overlapping laminae; ribs sessile. Scales present. Rostrum rounded in transverse section; teeth present; a prædentary bone; nasals broadly attached to anterior edges of frontals; maxillary of nearly equal width throughout its length.

Histiophorus and *Tetrapturus*, perhaps dating back to the Eocene.

Family 3. *Blochiidae*.

24 vertebrae. Pelvic fins absent. Neural and hæmal spines not expanded. Ribs apparently sessile. Body covered with slightly imbricated, diamond-shaped, bony scutes; two longitudinal series of enlarged scutes on each side.

Blochius longirostris, from the Upper Eocene of Monte Bolca, attaining a length of one metre.

Family 4. *Xiphiidae*.

26 vertebrae. Pelvic fins absent. Neural and hæmal spines not expanded. Ribs inserted on transverse processes. Scales absent in the adult. Rostrum depressed; no teeth in the adult; no prædentary bone; nasals extending back on each side of the ethmoid and just reaching the frontals; maxillary formed of an expanded anterior and a rod-like posterior portion.

The adult *Xiphias gladius* differs considerably from *Blochius*, but very young specimens clearly show its relationship to the extinct genus. An example of nearly 200 mm. in the British Museum is very similar to *Blochius longirostris*, resembling it in the long slender jaws, the elongate body with the greatest depth just behind the head, and the continuous dorsal fin. The body is covered with rough, non-imbricated scales, with 4 longitudinal series of enlarged scales on each side, 2 corresponding in position to the lateral series in *Blochius* and the others running at the base of the dorsal and anal fins.

The Lower Eocene *Acestrus* may belong to the *Xiphiidae*.

Family 5. Xiphiorhynchidæ.

Rostrum rounded in transverse section; teeth present; nasals widely separated from the frontals by the broad ethmoid; maxillary formed of an expanded anterior and a rod-like posterior portion.

Xiphiorhynchus of the Lower and Middle Eocene.

XII.—*The Classification of Teleostean Fishes.*

By C. TATE REGAN, M.A.

BEFORE proceeding to the classification of the Teleostei two questions must be discussed, viz. the rank and the limits of the group.

I have already expressed the opinion that the true Fishes are at least as distinct from the Selachians on the one hand and the Batrachians on the other as any of the vertebrate classes are from each other, and are equally entitled to rank as a class*. The class Pisces differs from the Selachii in the presence of two external nasal openings on each side; the reduction of the interbranchial septa; the development of an air-bladder or lung; the bony exoskeleton, typically including paired nasal, frontal and parietal bones, a parasphenoid, an operculum, a series of bones, post-temporal, supra-cleithrum, cleithrum and clavicle, overlying the primary pectoral arch and connecting it with the cranium, scales and articulated fin-rays; the development of bones in or on the visceral arches, præmaxilla, maxilla, palatine, pterygoids, quadrate, dentary, &c.; the presence of supra-neural arches (well-developed in Chondrostei and Dipneusti, less evident when centra are formed). The Batrachians are separated from the Pisces especially by the presence of true internal nares and of a *fenestra ovalis*, the modification of the paired fins into pentadactyle limbs and of the hyomandibular into the stapes, and the absence of endoskeletal supports and dermal rays from the median fins.

Whilst recognizing the importance of the characters which distinguish the Pisces from the Selachii, I have hitherto been so conservative as to regard these groups as sub-classes only, using the name Teleostomi for the former. The groups which I formerly recognized as orders of the sub-class

* Regan, Proc. Zool. Soc. 1906, p. 724, and Biol. Centr.-Am., Pisces, p. viii (1908).